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POSSIBILITIES OF WOOD-PULP PRODUCTION IN THE NORTHERN ROCKY MOUNTAIN REGION

by

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Purpose of Report

In the Northern Rocky Mountain Region there are large supplies of timber available which are suitable for conversion into wood pulp. It is estimated that in northwestern Montana and northern Idaho there are 11,000,000 cords of mature Engelmann spruce, 13,700,000 cords of grand (white) fir, and 2,100,000 cords of western hemlock plus less important pulp species such as lodgepole pine and northern black cottonwood. This volume of timber, assuming it is cut piece by piece, is sufficient to supply a sulfite mill having a daily capacity of 100 tons of pulp, for 500 years.

It happens that the pulp species mentioned above are not in great demand for lumber and it naturally follows that incomplete utilization of the forest resource results. In the enthusiasm to obtain a more complete utilization of the forests of the Northern Rocky Mountain Region, the proposal is often made that more pulp mills should be established. The only plant in the region at present is the Inland Empire Pulp and Paper Company located at Millwood on the outskirts of Spokane.

This report will attempt to analyze the possibilities of establishing more plants. It is written primarily for the use of Forest Service personnel who from time to time are asked the question, "What are the possibilities for pulp and paper mills?"

Admittedly there is plenty of timber available, plenty of clean water, plenty of fuel, and hundreds of miles of streams with power potentialities. But the source and available supply of raw materials is only one of many factors which must be investigated before it can be determined whether the production of pulp will pay. First of all, what kind of pulp should be produced: sulfite, sulphate, soda, or groundwood? Should bleached or unbleached pulp be manufactured? What species are best suited to each process? Should the pulp be shipped to distant paper mills or should integrated pulp and paper mills be built? Where are the known markets? What are the possibilities of shipping pulp logs and chips to distant mills?

It is easy to see that this investigation of wood pulp possibilities covers a broad field. Information must be given on plant-investment costs, cost of manufacture, markets, competition from other regions, suitability of local woods for pulp, etc. As a starting point, a brief description will be given of the processes by means of which wood is converted into pulp.

General Manufacturing Processes

There are five general processes for converting wood to the pulp condition. They are known as the groundwood, sulfite, sulphate, soda, and semichemical.

The groundwood process of pulping is used mainly for the conversion of light-colored, nonresinous, long-fibred woods such as spruce and white fir. It is accomplished by grinding the barked wood on a grindstone, the surface of which has been especially sharpened to give a cutting action. The yield of pulp is approximately 90 percent based on the raw wood weight. The pulp is inferior and in paper-making is usually used in admixture with longer and stronger fibred pulp, such as sulfite, in the manufacture of paper products such as newsprint, catalog, magazine, and certain other papers in which neither high strength nor permanency is required. It is also used in large quantities in the manufacture of some wallboards.

The sulfite process, also spelled "sulphite," is employed mainly for the conversion of the "preferred" species such as spruce, white fir and hemlock, which are long fibred, nonresinous, easily bleached, and possessed of other desirable properties. In this process the wood is chipped, and then cooked with a solution of calcium bisulphite and sulphurous acid until it is reduced to a pulp essentially free from lignin. The process gives a pulp yield of about 45 percent, based on the original weight of the wood. This pulp, generally light

colored in the unbleached condition, can be easily bleached to an extreme whiteness and is used both unbleached and bleached in the manufacture of book paper, newsprint, wrapping, bonds, and tissues. Purified, bleached sulfite pulp is used in the manufacture of viscose rayon and other cellulose derivatives. At present sulfite pulp is adaptable to the widest variety of uses of any of the commercial pulps.

The sulphate or kraft process ("kraft" is a German word meaning strong) of pulping is used principally for the conversion of southern pine and jack pine. The term "sulphate" originates because sodium sulphate is the chief chemical used in renovating the cooking liquor. Like the sulfite, the sulphate is a cooking process in which essentially all of the lignin is dissolved from the wood. The process gives a yield of about 45 percent based on the original weight of the wood. It is an alkaline process of pulping - the active chemicals are caustic soda and sodium sulphide - and can be used in the conversion of almost any wood including Douglas-fir and larch. Ordinarily only the cheaper resinous woods are used in this process. Kraft pulp is ordinarily not bleached but on account of its strength is used for the manufacture of kraft wrapping paper and high-test fibreboard boxes. During recent years, however, considerable progress has been made in the bleaching of kraft pulp and this grade is now produced in an appreciable quantity.

The soda process of pulping is a cooking process which is used mostly for reduction of short-fibred hardwoods, such as cottonwood. It gives a yield of less than 45 percent. The resulting pulp is invariably bleached to a high degree of whiteness and is used in the manufacture of book papers, lithograph, envelopes, etc., usually in mixture with some long-fibred pulp. The only soda mill in the Pacific Northwest is the plant of the Everett Pulp and Paper Company at Everett, Washington, one of the oldest plants on the coast. This company has acquired considerable cottonwood in the Bonners Ferry (Idaho) region. When the writer worked for the company in 1930 it shipped cottonwood from Bonners Ferry, but it has not shipped much in recent years.

In the semichemical processes wood chips are subjected to a mild digestion which removes only a part of the lignin. The softened chips are then disintegrated mechanically to pulp by grinding in a refiner. Although any of various kinds of pulping liquor may be used for the preliminary digestion, the method developed at the Forest Products Laboratory about 15 years ago, employing a sodium monosulfite liquor, is the most widely used. Pulp yields up to 80 percent of the wood weight are obtainable. Such pulps are used for boards and coarse papers.

Wood pulp is transferred to the paper mill in the form of slush, wet laps, or air-dried pulp. If a pulp and a paper mill are operating in combination, the pulp is usually transferred to the paper plant as slush, a water solution containing 5 or 6 percent fibre, as this eliminates the expense of drying and lapping. If the pulp is to be stored, and this is often necessary, or if it is to be shipped only a short distance, it is thickened and made into long, continuous sheets which are cut and folded or lapped. These wet laps contain about half water and half fibre. For long-distance shipment the pulp is usually dried so that it contains about 10 percent moisture and 90 percent fibre. It may be shipped in rolls, in sheets, or be shredded and baled. Pulp with 10 percent moisture is called "air-dry" and wherever this term is hereafter used it means pulp with 10 percent moisture. Prices and quantities of pulp are usually expressed on this basis.

Species Suitable for Pulping

Spruce has always been the most desirable species for pulping. When a shortage of spruce began to be felt in the East, other species were substituted. This was done not as a matter of choice but through necessity, and does not obviate the fact that spruce is still the premier pulping species particularly for sulfite and groundwood pulp.

Although exact figures are not available, the writer made an estimate [1/] which showed that at least up until 1935 70 percent of the wood pulp and paper consumed in the United States was made from spruce, and that of this 70 percent about two thirds was imported in the form of pulpwood, pulp, newsprint, or some other finished paper product. However, the increase in domestic pulp production as a result of the rapid development of the kraft industry in the South and the expansion of the sulfite industry on the West Coast, based on species other than spruce, tends to make the percentage of spruce become smaller.

[1/] Production, import, and export figures by pulping processes were available and the calculation as to the percent of spruce used involved the following assumptions; namely, that 60 percent of the domestic sulfite pulp and 80 percent of the domestic groundwood pulp were made from spruce, and that 80 percent of the imported sulfite and groundwood pulp and 80 percent of the imported newsprint were made from spruce. It was assumed that no spruce was used in other pulping processes, which is not strictly true.

Native Species

Although the most important woods within reach of established wood-pulp mills are already in use, there are some species in remote areas such as the Northern Rocky Mountain Region which possess good pulping qualities though they have not been utilized for this purpose to any extent. Chief among these woods are Engelmann spruce, white fir, western hemlock, lodgepole pine, and ponderosa pine. Engelmann spruce closely resembles white spruce (an eastern species); grand (white) fir and hemlock are widely used on the Pacific Coast as well as by the Inland Empire Pulp and Paper Company at Spokane; lodgepole pine closely resembles jack pine (an eastern species); and ponderosa pine falls between southern yellow pine and the white pines in its pulping characteristics. Both lodgepole pine and ponderosa pine are amenable to the sulphate process, and might with further research be suitable for sulfite.

The suitability of some of the local species for groundwood, sulfite, and sulphate pulp as determined by the Forest Products Laboratory, Madison, Wisconsin, is briefly given in the next three pages. Eastern spruce, the best known species of the East, is listed as a standard for comparison although it does not occur locally.

Groundwood Process

White spruce (P. glauca); fiber length, 2.8 mm.
Conversion: Reduces readily.
Pulp: Of excellent quality and standard strength.
Power needed: 60 to 80 horsepower-days per ton of pulp.
Uses of pulp: Wide range.

Engelmann spruce (P. Engelmannii); fiber length, 3.0 mm.
Conversion: Reduces readily.
Pulp: Of excellent color and standard strength.
Power needed: Comparable to white spruce.
Uses of pulp: Wide range.

Lodgepole pine (P. contorta); fiber length, 2.3 mm.
Conversion: Reduces readily.
Pulp: Of excellent color and standard strength.
Power needed: 15 to 25 percent more than for white spruce.
Uses of pulp: Wide range.

Ponderosa pine (P. ponderosa); fiber length, 3.6 mm.
Conversion: Reduces fairly readily.
Pulp: Of satisfactory color and soft texture; coarser than spruce; some is apt to be pitchy.
Power needed: 40 to 50 percent more than for spruce to obtain pulp with the same strength.
Uses of pulp: Limited.

Lowland white (grand) fir (A. grandis); fiber length, 3.2 mm.
Conversion: Reduces readily.
Pulp: Of excellent color.
Power needed: 15 to 25 percent more than for spruce.
Uses of pulp: Wide range.

Douglas-fir (P. taxifolia); fiber length, 4.4 mm.
Too resinous for grinding and too dark for pulp.

Western hemlock (T. heterophylla); fiber length, 2.7 mm.
Conversion: Reduces readily.
Pulp: Of excellent color and standard strength.
Power needed: 10 to 15 percent more than for spruce.
Uses of pulp: Wide range.

Western larch (L. occidentalis); fiber length, 2.6 mm.
Conversion: Reduces with difficulty.
Pulp: Of poor color; coarse.
Power needed: 2½ times that for spruce.
Uses of pulp: Very limited.

White spruce
Conversion: Reduces readily.
Unbleached pulp: Strong, fine texture, excellent color, occasionally somewhat pitchy, bleaches easily to excellent white. Yields 45 to 50 percent.
Bleach needed: 10 to 20 percent.
Uses of pulp: Wide range.

Engelmann spruce
Conversion: Reduces readily.
Unbleached pulp: Strong, fine texture, excellent color, bleaches easily to excellent white. Yields 45 to 50 percent.
Bleach needed: 10 to 20 percent.
Uses of pulp: Wide range.

Lodgepole pine
Conversion: Reduces readily.
Unbleached pulp: Excellent color, fine fibred, very strong, sometimes somewhat pitchy; easily bleached. Yields 45 to 50 percent.
Bleach needed: 10 to 20 percent.
Uses of pulp: Not as wide as Engelmann spruce.

Ponderosa pine
Conversion: Reduces fairly readily but unevenly.
Unbleached pulp: Dark in color and rather coarse. Yields 45 to 50 percent.
Bleach needed: Probably more than 20 percent.
Uses of pulp: Limited.

Lowland white (grand) fir
Conversion: Reduces readily.
Unbleached pulp: Excellent color and strength, fibers somewhat coarser than spruce, fairly easily bleached. Yields 45 to 55 percent.
Bleach needed: 0 to 25 percent.
Uses of pulp: Wide range.

Douglas-fir
Conversion: Reduces with difficulty.
Unbleached pulp: Fair strength, poor color, pitchy. Yields 45 to 50 percent.
Bleach needed: 20 to 25 percent.
Uses of pulp: Very limited.

Western hemlock
Conversion: Reduces readily.
Unbleached pulp: Tough and strong, good color. Yields 45 to 50 percent.
Bleach needed: 15 to 20 percent.
Uses of pulp: Wide range.

Western larch
Conversion: Reduces with difficulty and unevenly.
Unbleached pulp: Brash, dark, bleaches fairly well. Yields 40 to 45 percent.
Bleach needed: 15 to 25 percent.
Uses of pulp: Very limited.

Sulphate (Kraft) Process

White spruce

Conversion: Reduces readily.

Unbleached pulp: Very strong, fine texture. Yields 45 to 50 percent of strong pulp, 38 to 43 percent of pulp for bleaching.

Bleach needed: 20 to 30 percent in one stage, or 15 to 20 percent in two stages.

Uses of pulp: Wide range.

Engelmann spruce

Conversion: Reduces readily.

Unbleached pulp: Strong, fine texture. Yields 45 to 50 percent of strong pulp.

Bleach needed: Comparable to white spruce.

Uses of pulp: Wide range.

Lodgepole pine

Conversion: Reduces readily.

Unbleached pulp: Very strong. Yields 45 to 50 percent of strong pulp.

Bleach needed: Over 20 percent in one stage, or 15 to 20 percent in two stages.

Uses of pulp: Wide range.

Ponderosa pine

Conversion: Reduces readily.

Unbleached pulp: Very strong, the long fine fibers having exceptionally good felting properties. Yields 45 to 50 percent.

Bleach needed: Probably more than 25 percent.

Uses of pulp: Wide range.

Lowland white (grand) fir

Conversion: Reduces readily.

Unbleached pulp: Very strong. Yields 45 to 50 percent of strong pulp, 35 to 45 percent of pulp for bleaching.

Bleach needed: 20 to 30 percent.

Uses of pulp: Wide range.

Douglas-fir

Conversion: Reduces readily.

Unbleached pulp: Fairly strong, not as strong as most. Yields 45 to 50 percent.

Uses of pulp: Not suitable where great strength is needed.

Western hemlock

Conversion: Reduces readily.

Unbleached pulp: Very strong and tough. Yields 45 to 50 percent of strong pulp.

Bleach needed: 20 to 30 percent in one stage, 10 to 20 percent in two stages.

Uses of pulp: Wide range.

Western larch

Conversion: Reduces readily.

Unbleached pulp: Very strong. Yields 45 to 50 percent of strong pulp.

Uses of pulp: Wide range.

Advantages and Disadvantages of Pulp Mill to Local Economy

No other large-scale method of timber utilization equals that of pulp manufacture in the completeness with which the raw material (the tree) is utilized. It can also be said with a great deal of assurance that the pulp and paper industry is up and coming. Its production curve is still headed upward and more plants are being built each year.

Pulp and paper manufactories constitute the one great industry using wood in which there is much hope for forestry as a commercial undertaking, both public and private. The production of pulpwood of rapidly growing species on good sites is a matter of much shorter time than the growing of sawtimber. There is also more permanency to a pulp and paper operation than is true of most wood-using industries.

From a utilization standpoint the establishment of pulp mills is desirable in the Northern Rocky Mountain Region because such plants use species which are not regarded with high favor for lumber by sawmill men.

Then too, the operation of a pulp and paper mill offers regularity of employment since the nature of the technical operations is such that it is inadvisable to run the mill sporadically. If the mill runs at all, it must run steadily. Pulp

mills also offer good wages. In a sulfite pulp mill about 25 percent of the employees fall in the skilled category (acid makers, cooks, bleachermen, etc.), 40 percent are semiskilled (cooks' helpers, blow-pit men, wood cleaners, etc.), and only 35 percent are unskilled workers such as wood handlers, limestone handlers, and common laborers. In a paper mill the percent of skilled workers is still higher, but in the woods operation the proportion of skilled workers decreases and the number of unskilled increases.

Another important social asset of a pulp mill is the quantity of employment that it provides. In this connection the writer estimates that a 100-ton sulfite mill manufacturing bleached air-dry pulp will require the services of approximately 300 employees including those engaged in the logging. The annual payroll will probably be in the neighborhood of $400,000.

There are also some drawbacks to the establishments of pulp mills, the greatest of which is the probability of additional stream pollution. If this is likely there will be cause for furore among recreationists, especially fishermen, as well as those who depend upon the recreation industry for a livelihood.

Present Local Industry and Its Markets

As mentioned before, the only pulp and paper mill in the region is the plant of the Inland Empire Pulp and Paper Company. It is usually conceded that the amount of paper produced by this plant is sufficient to supply the wants of this region.

The paper mill of this company has a reported daily capacity of 65 tons of newsprint and 50 tons of sulfites. The percent of capacity which has been used recently is not known. The company can ship newsprint west of Spokane only a short distance before it begins to feel the competition of Puget Sound mills. Eastward it can normally ship as far as Billings, Montana. In the Dakotas the market is usually held by mills in the Lake States. Colorado is within the trade territory of the Spokane mill, to some extent at least, but the manufacture of news in the Southern States may change this picture.

Different grades of newsprint as well as a variety of other papers and products are manufactured by the Spokane plant. Among these products are News in rolls and sheets in white, cream, and colors; High-grade news (Special halftone and Magazine print); Mimeograph news in white and six colors; Coarse papers (car linings, screenings, ham wrap, sheathing);

No. 4 Bonds and Mimeo bonds; Book (Eggshell, and English finish); Envelope; Wrappings of various kinds; and sulfite and groundwood specialties.

The pulp mill of this company is reported to have a daily capacity of 100 tons of groundwood and 33 tons of sulfite pulp. The species used are white fir, Engelmann spruce, hemlock, and cottonwood, by amount in the approximate order named. The proportion of each varies from year to year depending upon its availability and the products being manufactured. The company does no logging and obtains its wood supply from private operators in the form of sawlogs.

Possible Markets for Additional Paper Mills

It can be said with quite a bit of assurance that there is little or no market within the Northern Rocky Mountain Region for the products of a second paper mill. Such a mill would be in cutthroat competition with the Spokane mill, and since the local market is limited in size the resulting competition would probably be disastrous for both.

Whether paper could be manufactured in this region and shipped elsewhere requires more study than the writer has given the subject, as it has many angles. It does not appear offhand, however, that such a venture would be profitable. There are several reasons for believing this, one being that

markets east and west of here are in the trade territory of paper mills in the Lake States and the Pacific States respectively, and since these mills are favorably situated it would be difficult in normal times for a local mill to enter these markets at a profit. Then too, there is frequently an advantage in manufacturing paper near the markets for paper, one reason being that the freight on paper is higher than for pulp.

Possible Markets for Additional Pulp Mills

The United States imports large quantities of wood pulp, much of which has been coming from Europe. Since the war began imports have been sharply curtailed. But even in normal times the demand for pulp is far in excess of the domestic supply. As long as the United States is not self-sustaining there are possibilities of establishing pulp mills in the Northern Rocky Mountain Region, where large supplies of species suitable for pulp are available for conversion.

Most of the pulp now imported by the United States is processed by paper mills in the Lake States and the Northeastern States. In recent years the pulp mills in the Lake States have been producing only about half the pulp consumed by the paper mills in the same territory. In 1935, as table 1 on the next page shows, the paper mills in the Lake States consumed 1,814,000 tons of pulp and in the same year the local pulp

mills produced only 932,000 tons. Imports amounted to 882,000 tons, of which 537,000 tons were sulfite. Of this sulfite tonnage, 500,000 tons can be accounted for as follows: from Europe (chiefly Sweden), 339,000 tons; from the Pacific States, 85,000 tons; from Canada, 76,000 tons. A shortage of spruce wood or pulp of the proper grade undoubtedly accounts for these sulfite imports. It might be mentioned in passing that there are different grades or qualities of sulfite pulp just as there are different grades of lumber. [2]

Table 1.- 1935 production and consumption of wood pulp in the Lake States, expressed in thousands of tons.

Kind of pulp	Production of pulp mills	Consumption [1] by paper mills	Apparent imports
Sulfite	370	907	537
Groundwood	284	372	88
Sulphate	217	426	209
Other	61	109	48
Total	932	1,814	882

[1] Includes mills in adjoining Central States.

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[2] Types of bleached sulfite pulp can be briefly described as follows: Superpurified - Contains a very high percentage of alpha cellulose, quite pure, and has an excellent color; used for very high grades of paper, nitrocellulose and other special military and industrial products, and chemical compounds. Rayon - Contains a high percentage of alpha cellulose and is used for rayon and other textiles. Paper grades - Used chiefly for paper manufacture; several classes of pulp are recognized, among which are (a) special or select pulp including bleached Mitscherlich, (b) bond, and (c) book or soft-book sulfite.

Any pulp mill built in the Northern Rocky Mountain Region would be dependent upon the situation in the Lake States, as these States present the potential markets. Mills must also be in close touch with the situation in the Pacific States as these States play the roll of competitors. As table 2 shows, the Pacific States are not importers of pulp, but exporters. Normally the only pulp which the Pacific States export is sulfite. Sulfite pulp finds a broad domestic as well as world market. Cheaper pulps such as groundwood and sulphate are usually made into paper in integrated pulp and paper mills as their price does not justify long-distance shipment. Statistics for the United States show that 90 percent of the groundwood and sulphate pulp is made into paper near the source of the wood supply and near the market for the final product. This point is important and will be referred to again when the possibilities of establishing groundwood mills in the Northern Rocky Mountain Region are considered.

Table 2.- 1935 production and consumption of wood pulp in the Pacific States, expressed in thousands of tons.

Kind of pulp	Production of pulp mills	Consumption by paper mills	Apparent exports or imports
Sulfite	559	246	313 exports
Groundwood	258	271	13 imports
Sulphate	190	203	13 imports
Other	33	34	1 import
Total	1,040	754	286 exports

The Pacific States constitute the only forest region in the United States from which sulfite pulp is exported in quantities. Although their surplus pulp enters world markets, a large proportion of the tonnage shipped is converted into paper within the confines of the United States, chiefly by mills in the Lake States and the Northeast. Some sulfite pulp from the Pacific States goes by rail to the Lake States, and much is also shipped to the eastern seaboard and back-hauled as far east as Ohio.

If another pulp mill is built in this region, it can be assumed with little fear of contradiction that the Lake States present the best potential markets. Obviously pulp could not be shipped westward to the Pacific Coast where there is no shortage of wood pulp. Nor is it likely that pulp could be shipped, except under unusual circumstances, to mills in the Northeast because of the long rail haul which would cost so much more than water transportation from the Pacific States or from Europe.

Assuming that the Lake States present a potential market, what kind of pulp should be produced? Soda pulp is out of the question because its production requires large supplies of hardwoods and these are not available in this region. The situation with respect to groundwood pulp and sulphate pulp is not much better, but for a different reason. Although there is some demand for these pulps in the Lake States, it is not

likely that they could be shipped there at a profit. The distance is too great, and furthermore it would be necessary to lap and air-dry the pulp which would add considerable to production costs. At present these pulps are produced in integrated pulp and paper mills where lapping and drying is avoided whenever possible. With soda, groundwood, and sulphate pulp eliminated from consideration, or nearly so, the remaining possibility centers around sulfite pulp. This pulp seems to have the best possibilities. It brings the highest price, there is an abundance of timber available for the process, and such pulp always has a good demand in the Lake States.

Cost of Producing Wood Pulp

Now the question arises: For what cost can the pulp be delivered in the Lake States and what price will it bring?

Two cost estimates appear in the following pages, table 3 being for groundwood pulp and table 4, for sulfite. In each case the cost of production is compared for mills in the Lake States, the Pacific States, and the northern Rocky Mountain States. Costs for the first two regions named are for 1934 and were obtained from Report No. 126, second series, of the U. S. Tariff Commission. Costs for the Northern Rocky Mountain Region were estimated by the writer and are based on conditions which existed in 1934. Costs and prices for 1934 were used in every case because they were readily available and are probably more nearly normal than the prices of today (January 1941).

Groundwood

The cost of producing groundwood pulp in the three regions appears in table 3. Groundwood pulp is used mostly in slush form in integrated pulp and newsprint mills in the Lake States and the Pacific States; hence these mills have a considerable advantage over a local mill which would need to lap the pulp, dry, bale, and ship it a great distance.

The pith of table 3 with respect to the establishment of a groundwood pulp mill in this region appears in the lower right-hand corner. The figures there show that the cost of producing the pulp and shipping it to Appleton, Wisconsin, would be $36.02 per ton and the value of the pulp would be $27 per ton, resulting in a deficit of $9.02 per ton or about $900 a day for a 100-ton plant.

Sulfite

Comparative costs of producing bleached and unbleached sulfite pulp appear in table 4. The situation with respect to the production of bleached sulfite pulp in this region is much more rosy than for groundwood pulp. The production of unbleached sulfite does not have a great deal to recommend it, however. Engelmann spruce is amenable to bleaching and it is for this species that the costs in table 4 are figured.

Table 3. - Cost in dollars per ton (air-dry fibre content) of manufacturing groundwood wood pulp based on conditions as they existed in 1934.

Item	Lake States			Pacific States			Northern Rocky Mountain States			
	Slush pulp	Lapping	Drying and baling	Slush pulp	Lapping	Drying and baling	Slush pulp	Lapping	Drying and baling	Total
Operating costs:										
Wood	8.93	-	None prepared in this form. Nor is lapping done except when surplus supplies are stored.	6.85	-	None prepared in this form. Nor is lapping done except when surplus supplies are stored.	8.00	-	-	8.00
Labor	2.77	2.38		2.10	.54		2.10	.50	.90	3.50
Power	4.04	.14		4.31	.39		4.25	.40	1.15	5.80
Supplies	.50	-		.24	-		.50	-	.60	1.10
Repairs	1.00	-		1.02	-		1.01	-	-	1.01
Other mill expense	.66	1.50		.53	.82		.60	.60	.50	1.70
Administrative expense	.72	.19		.85	.09		.80	.10	.12	1.02
By-products (subtract)	-	-		.05	-		-	-	-	0.00
Total	18.62	4.21		15.95	1.84		17.26	1.60	3.27	22.13
Overhead costs (see footnote):										
Depreciation, taxes, insurance	2.85	.38		1.73	.16		2.00	.24	.30	2.54
Interest	3.31	.45		1.86	.16		2.50	.15	.20	2.85
Total	6.16	.83		3.59	.32		4.50	.39	.50	5.39
Total cost	24.78	5.04		19.54	2.16		21.76	1.99	3.77	27.52
Estimated freight to Appleton, Wisc.										8.50
Cost per ton of pulp, F.O.B. Appleton										36.02
Estimated value of pulp in Appleton										27.00
Amount available for profit and risk									(Deficit)	9.02

Overhead costs vary greatly. They increase when the plant runs at low capacity and decrease with a full production schedule. The item of interest is at the rate of 6 percent and applies to plant investments and inventories but not to timber lands. Strictly speaking, interest is not a cost unless money is borrowed. Herein interest is added to other costs, but the real intent in using interest in the calculations is to give some measure of the attractiveness of the investment.

Table 4. - Cost in dollars per ton (air-dry fibre content) of manufacturing bleached and unbleached sulfite pulp of paper grade, based on conditions as they existed in 1934.

Item	Lake States						Pacific States						Northern Rocky Mountain States					
	Unbleached slush pulp	Bleaching	Lapping	Drying and baling	Total - unbleached, in wet laps	Total - bleached, in wet laps	Unbleached slush pulp	Bleaching	Lapping	Drying and baling	Total - unbleached, air-dry and baled	Total - bleached, air-dry and baled	Unbleached slush pulp	Bleaching	Lapping	Drying and baling	Total - unbleached, air-dry and baled	Total - bleached, air-dry and baled
Operating costs:																		
Wood	19.36	-	-		19.36	19.36	10.75	-	-	-	10.75	10.75	13.25	-	-	-	13.25	13.25
Chemicals	3.99	3.57	-		3.99	7.56	3.82	2.97	-	-	3.82	6.79	3.90	2.80	-	-	3.90	6.70
Labor	3.45	.77	1.25	None	4.70	5.47	2.59	.49	1.44	1.00	5.03	5.52	2.60	.50	1.30	.90	4.80	5.30
Power	4.25	1.14	.47	pre-	4.72	5.86	2.98	1.18	.13	1.14	4.25	5.43	3.00	1.20	.25	1.15	4.40	5.60
Supplies	.48	.12	.40	pared	.88	1.00	.16	.05	.66	.56	1.38	1.43	.40	.15	.52	.60	1.52	1.67
Repairs	1.51	.28	.19	in	1.70	1.98	1.96	.60	.29	.58	2.83	3.43	2.00	.60	.30	.60	2.90	3.50
Other mill expense	1.51	.23	.28	this	1.79	2.02	.62	.29	.16	.32	1.10	1.39	1.00	.27	.20	.50	1.70	1.97
Loss in bleaching	-	3.14	-	form.	-	3.14	-	2.09	-	-	0.00	2.09	-	2.00	-	-	0.00	2.00
Administrative expense	0.96	.17	.06		1.02	1.19	1.11	.23	.14	.15	1.40	1.63	1.00	.20	.16	.12	1.28	1.48
By-products (subtract)	-0.27	-	-		-0.27	-0.27	-0.21	-	-	-	-0.21	-0.21	-0.20	-	-	-	-0.20	-0.20
Total	35.24	9.42	2.65		37.89	47.31	23.78	7.90	2.82	3.75	30.35	38.25	26.95	7.72	2.73	3.87	33.55	41.27
Overhead costs (see footnote):																		
Depreciation, taxes, insurance	2.28	.43	.10		2.38	2.81	2.11	.69	.14	.56	2.81	3.50	2.15	.60	.12	.30	2.57	3.17
Interest	2.72	.79	.23		2.95	3.74	2.23	1.02	.15	.61	2.99	4.01	2.50	1.00	.14	.20	2.84	3.84
Total	5.00	1.22	.33		5.33	6.55	4.34	1.71	.29	1.17	5.80	7.51	4.65	1.60	.26	.50	5.41	7.01
Total cost	40.24	10.64	2.98		43.22	53.86	28.12	9.61	3.11	4.92	36.15	45.76	31.60	9.32	2.99	4.37	38.96	48.28
Estimated freight to Appleton, Wisconsin					-	-					9.20	9.20					8.50	8.50
Cost per ton of pulp, F.O.B. Appleton					43.22	53.86					45.35	54.96					47.46	56.78
Estimated value of pulp at Appleton					45.00	57.50					45.00	57.50					45.00	57.50
Amount available for profit and risk (Note: "D" indicates deficit)					1.78	3.64					0.35D	2.54					2.46D	0.72

Overhead costs vary greatly. They increase when the plant runs at low capacity and decrease with a full production schedule. The item of interest is at the rate of 6 percent and applies to plant investments and inventories but not to timber lands. Strictly speaking, interest is not a cost unless money is borrowed. Herein interest is added to other costs, but the real intent in using interest in the calculations is to give some measure of the attractiveness of the investment.

So far as this region is concerned, the margin available for profit and risk in producing bleached sulfite pulp is estimated to be 72 cents per ton over and above a 6-percent return on the investment. Ordinarily it would appear that a price of $60 per ton for pulp of paper grade would be needed to make the proposition highly attractive. (Note: The price in the forepart of 1941 is about $75 per ton.) The price used in the table of $57.50 per ton F.O.B. Appleton is for bleached pulp of paper grade as of 1934. Little is known of the suitability of Engelmann spruce for the higher grades such as "superpurified" and "rayon." These pulps are very valuable.

Since 1934 the trend in the price of bleached sulfite pulp has been erratic, but, except for a brief period in the winter of 1937-1938 when a little business boom got under way, prices have been below the 1934 average. At present (winter of 1940-1941) the price of pulp is undergoing a boom and phenomenal prices are being received. How long such prices will continue is anyone's guess. Costs of production have also moved upward since 1934, particularly the cost of labor. Freight rates on pulp from the Pacific Coast to eastern points have also increased. Comparisons of pulp prices and hourly wage rates during the past few years appear in tables 5 and 6. These give some indication of trends.

Table 5.-Approximate price of bleached sulfite pulp of paper grade at Atlantic ports, 1928-1941.

Year	Domestic pulp	Foreign pulp
	Dollars per ton	Dollars per ton
1928	80	68-77
1929	80-75	77-69
1930	75-65	69-58
1931	65-50	58-45
1932	50-35	45-35
1933	35-60	35-55
1934	60-55	55
1935	55-50	55-50
1936	50-53	50-65
1937	53-70	65-95
1938	70-50	95-47
1939	50	50-60
1940-1941, winter	75-80?	

Table 6.-Average hourly wage in pulp and paper manufacture. (Does not include logging.)

Year	Pacific States	Lake States
	Cents per hour	Cents per hour
1934	58.3	52.6
1935	62.0	53.9
1936	66.9	54.9
1937	79.7	65.1
1938	79.6	65.1
1939	79.8	65.6

As a matter of interest, average hourly wages paid in 1939 in pulp mills in some other countries follow: Japan, 6.4 cents; Finland, 16.6 cents; Great Britain, 27.0 cents; Germany, 30.5 cents; Sweden, 33.5 cents. The United States average (1939) was about 65 cents.

The cost analysis given in table 4, based on 1934 conditions, does not paint an extremely rosy picture, even for bleached sulfite pulp. On the other hand, some of the disadvantages now apparent may vanish as time goes on. It is likely that each year will see an improvement in the possibilities as far as the Northern Rocky Mountain Region is concerned and the chances are that the possibilities will not become worse. The region has many basic natural resources and in time these will be called into play.

No one knows what the future holds. It is known, however, that the United States has been depending upon Europe for supplies of bleached sulfite pulp. So has South America. Many of the pulp-producing countries of Europe are now dominated by Germany. If our relations with Germany continue as bad as they have in the past, it is possible even when peace returns to the world that the Congress will erect barriers against the importations of such pulp, assuming that Germany wins the present war or is not decisively defeated. South America also presents markets for pulp. The Pan-American Union is making a determined drive to improve inter-American trade relations. Will the United States supply pulp to South America, or will Europe?

Irrespective of the outcome of wars and Latin American relations, there are still possibilities, particularly in the case of plants in the Lake States which have a large amount of paper-mill capacity but lack domestic supplies of sulfite pulp. Such companies might find it worth their while to establish a sulfite pulp plant here. The plant would be an ace-in-the-hole, so to speak. During many years the plant itself might not make much money in selling pulp on the open market, but it would serve as a means of protecting the investment in paper-mill facilities whenever pulp shortages occur.

If a plant capable of producing bleached sulfite pulp for shipment to the Lake States were operating today it would be a money-maker. A word of caution, however. This may be a boom period and booms do not last forever.

Requirements for Pulp-Mill Establishment

The basic requirements for the establishment of a sulfite pulp mill can be listed as follows:

1. A large initial investment.
2. A large continuous wood supply.
3. Cheap chemicals.
4. Plenty of clean water of suitable quality.
5. Plenty of cheap power and fuel.
6. Provision for waste disposal.
7. Adequate transportation facilities.
8. Good markets.
9. An adequate supply of labor.

Although there are several possible sites for a sulfite pulp mill in the Northern Rocky Mountain Region, the writer hesitates at discussing them in detail at this time.

Investment

It is usually estimated that the investment required in a sulfite mill which is equipped to produce bleached air-dry pulp will be about $25,000 per ton of daily capacity. For a 100-ton plant about $2,500,000 will be required. Investments in timber will be extra. Costs may be higher or lower than stated depending upon where the plant is located, the amount of power development needed, etc. Ordinarily a 75- to 100-ton plant is the smallest size which can be run economically. Mosts plants are as large or larger.

Wood Supply

As was mentioned in the first paragraph of this report, there are large supplies of the "de luxe" pulpwoods available. The supply in northern Idaho and northwestern Montana is estimated at 11,000,000 cords of Engelmann spruce, 13,700,000 cords of grand (white) fir, and 2,100,000 cords of western hemlock. An estimate by districts appears in table 7. These figures were supplied by co-workers of the writer in the Division of Forest Survey.

Table 7. - Volume of principal kinds of wood suitable for sulfite-pulp manufacture in northern Idaho and in northwestern Montana. 1/ (Figures given are in thousands of cords.)

Kind of wood	Northern Idaho			North-western Montana 2/	Total
	Kootenai, Benewah, and Shoshone Counties	Boundary and Bonner Counties	Clearwater, Idaho, Latah, Lewis, and Nez Perce Counties	Flathead and Lincoln Counties	
Engelmann spruce...	1,510	1,350	2,164	5,961	10,985
White fir..	2,694	756	9,585	656	13,691
Western hemlock..	696	1,189	128	97	2,110
Total......	4,900	3,295	11,877	6,714	26,786

1/ The figures given are for mature timber on commercial forest land. (Accessibility zones 1 and 2.)

2/ Figures for other counties in western Montana were not readily available at the time this compilation was made. It is generally conceded, however, that Flathead and Lincoln Counties contain the bulk of the pulpwood stands.

In the sulfite process, one cord (128 stacked cubic feet) of unbarked wood will yield approximately 990 pounds of screened pulp. This yield is predicated on the use of Engelmann spruce. Yields can also be computed in terms of peeled wood or in terms of board feet log scale. Approximate conversions are as follows: One cord of peeled wood equals 1.125 cords of unbarked wood; one thousand feet Scribner log scale equals two cords of unbarked wood.

A 100-ton sulfite mill will require about 200 cords of wood per day or 100 M feet of logs. For the production of bleached pulp this wood must be sound and free from blue stain, carbon (charred wood), and other discolorations which increase the cost of bleaching or make bleaching impossible. If carbon and bark are not entirely removed prior to chipping they appear as specks which detract materially from the value of the pulp and the finished paper.

If a pulp mill was reasonably well located with reference to the forest, logs could be delivered at the plant for a cost of about $12 per thousand feet Scribner scale. This cost would include stumpage, transportation, and all other items chargeable to logging. It would not, however, include the cost of peeling the logs. This estimate of costs is based on conditions as they existed in 1940.

Chemicals

The chief chemicals needed in the sulfite reduction process are limestone and sulphur plus chlorine or some chlorine compound for bleaching. It is reported that there are plenty of limestone deposits of the high calcium type in the Northern Rocky Mountain Region. Some are undeveloped, quite true, but there is little doubt that the stone will be available at low cost. Chlorine is also needed, but the writer knows little about available supplies. It could probably be manufactured about as cheaply here as elsewhere.

Sulphur is also needed and at present most of the sulphur used in sulfite-pulp manufacture comes from Louisiana and Texas. The cost delivered here will probably be somewhat higher than in most areas of sulfite-pulp production. In connection with sulphur demands, the use of sulphur dioxide from smelter fumes might well be investigated. It is known that sulphur dioxide can be used as a sulphur replacement. And it is known, too, that the production of liquid sulphur dioxide from smelter fumes is possible when ores containing pyrites are smelted. The smelter at Anaconda, Montana, can produce this product in large quantities, and perhaps the smelter at Kellogg, Idaho, also.

The extent of the writer's knowledge of the use of sulphur dioxide liquid as a sulphur replacement is as follows: For a time, about 1916, the Crown Willamette Paper Company in western Washington used sulphur dioxide gas, which was obtained in liquid form from the smelter at Tacoma, Washington, but the use was discontinued as there was no assurance that regular supplies could be obtained, for the reason that when the war of 1914-1918 started most of the supply was diverted to Dupont, Washington, for the manufacture of explosives. The paper company used the gas for about a year and found it entirely satisfactory. It is said that when the gas was used the cost of making sulphurous acid, which is used in sulfite cooking liquor, was less than the cost of using sulphur and making the acid by the tower method. The sulphur dioxide gas was compressed and shipped from the smelter to the plant in liquid form in tank cars.

Although the use of liquid sulphur dioxide has a technical advantage in that production of high-strength cooking acid is facilitated, its use is largely determined by its cost compared to that of burning sulphur for the production of sulphur dioxide gas at the pulp mill. Any mill within a reasonable distance of Anaconda would be wise, however, to study the possibilities of using the smelter by-product.

Water Supply

Water is another important raw material and pulp mills are always located near a good supply. Few sulfite mills use less than 40,000 gallons of process water per ton of pulp, and many use more. A 100-ton plant would need at least 4,000,000 gallons daily. Ordinarily a water supply should not be a problem even during the dry summer months if the mill is located along a major stream in western Montana or northern Idaho.

Power

Pulp plants require considerable power, and chemical plants need boiler horsepower particularly, for operation of the digesters and steam equipment. A 100-ton sulfite mill requires about 3,500 horsepower-days. Of this amount approximately half should be boiler horsepower and half motive (hydraulic, hydroelectric, boiler, or whichever is cheapest).

Electrical power will probably be as cheap in the Northern Rocky Mountain Region as in the Lake States if it can be purchased from some going commercial installation. If it is necessary to develop hydroelectric power locally, the cost will likely be higher. Fuel for boilers will under most conditions be as cheap as or cheaper than in the Lake States, especially if the pulp plant has access to supplies of hogged fuel from sawmills.

Waste Disposal

The disposal of pulp-mill effluents must be given serious consideration especially in Montana where the dumping of unpurified waste into streams is prohibited by statute. The people of northern Idaho and Washington are becoming accustomed to stream pollution, but not Montanans. Waste from sulfite mills although not toxic is particularly objectionable because of its high biochemical oxygen demand. It is estimated that a 100-ton sulfite mill is equivalent in this respect to a population of 300,000 people. For every ton of pulp manufactured approximately 2,400 gallons of waste liquor containing about 10 percent of dissolved solids are produced. In a 100-ton sulfite mill about 240,000 gallons are produced daily. It is charged that when these wastes are dumped into streams many species of fish and other aquatic life are killed or driven away. The only redeeming feature in the West as compared to the East is that the rapid-moving western streams will probably oxidize the effluents at a faster rate than the slow-moving eastern streams which are not well aerated. The size of the stream would be another factor. Waste liquor is presumably tolerated by fish if the flow is sufficient to maintain the necessary oxygen content.

Many attempts have been made to recover the constituents of the sulfite waste liquors in some usable form. Sulfite waste liquor has been prepared under various names for a road binder. Its acidity is neutralized with lime and it is then evaporated to 50 percent solids or even a dry powder. Whether a mill in the northern Rocky Mountains could market such a product successfully is not known. Possibilities are probably fair.

Another development still in a semicommercial stage is the so-called Tomlinson magnesia-base cooking and recovery system or modifications thereof. With this method magnesium oxide and sulphur dioxide are recovered and reused in the new batch of cooking liquor. In addition a large amount of byproduct steam is obtained. The main departure from conventional practice is in the use of magnesium oxide in place of calcium oxide (limestone) as the base of the cooking liquor. The objection to this method is the cost of the recovery plant, which amounts to about half a million dollars for a 100-ton sulfite plant, but if the installation is self-supporting this does not militate too strongly against the process. The method is now being tried experimentally at the Weyerhaeuser plant at Longview, Washington, and at the Cornwall, Ontario, plant of the Howard Smith Paper Company. It is reported that the Weyerhaeuser mill will soon operate its

entire commercial plant on this process and when the installation is completed essentially all of the pollution will be eliminated. The mill has a capacity of 200 tons of pulp per 24 hours and the cost of the proposed installation is reported to be about $750,000. Presumably the process can be operated at a small profit.

Another development which has reached a commercial stage is the recovery and use of calcium sulphite and the calcium salt of lignin sulfonic acid. The sulphite is reused in the cooking liquor. Part of the lignin is used in a special by-products plant for the manufacture of tanning agents, vanillin, and plastics, and the balance may be burned as fuel. The method was developed by the Marathon Paper Company, which is located 5 miles from Wausau, Wisconsin, the writer's home town. If all of the lignin is converted into by-products or burned, this process eliminates up to about 85 percent of the biochemical oxygen demand of the liquor. However, the price of fuel at the plant determines whether the material can be burned profitably. The process is controlled by private patents, but it is likely that license could be obtained for the recovery and use of calcium sulphite and burning the lignin as fuel. Because of limited markets for many of the by-products, such as vanillin, it is probable that this part of the process would not be licensed.

The day before this report was mimeographed, word came from the Forest Products Laboratory, Madison, Wisconsin, that the committee representing sulfite mills in Wisconsin has been experimenting with a trickling filter of the type used in sewage disposal. Small-scale tests have shown a reduction of about 80 percent of the biochemical oxygen demand for the waste sulfite liquor, and during the next year it is planned to extend the tests to a pilot-plant scale. This is purely a disposal method with no attempt to recover any value from the liquor, and would involve some expense.

Aeration of the waste sulfite prior to discharge into streams has been tried, and while this improves conditions somewhat it has not accomplished an acceptable answer and, of course, no by-products are obtained.

Another method of disposal has been by storage in old lake beds or in artificial basins. Some seepage almost always occurs, however, and the fermentation of the liquor causes foul odors which make living conditions disagreeable.

The pollution problem simmers down to this: The cheapest and easiest way of disposing of effluents is to dump them into a stream. This subjects the pulp companies to severe adverse criticism. In attempting to solve the pollution problem much money has been spent but the results have been meagre in most cases. The situation regarding stream pollution is certainly not hopeless but is not susceptible of an easy solution as far as sulfite plants are concerned. Sulphate plants and groundwood mills are somewhat better off. Pollution resulting from their operation is only about one tenth or less of that from sulfite mills of the same capacity.

Transportation

With respect to main-line transportation, the Northern Rocky Mountain Region is well served, in an easterly-westerly direction at least. The region is traversed easterly-westerly by three important rail lines, the Chicago, Milwaukee, St. Paul and Pacific, the Great Northern, and the Northern Pacific. The three lines enter Spokane, then strike out separately and converge again at the St. Paul-Minneapolis transfer. The Milwaukee line and the Northern Pacific have facilities for transferring traffic from one line to the other at Missoula

and at Butte. In a northerly-southerly direction, transportation facilities by rail are rather poor.

Nothing definite can be said about the cost of shipping wood pulp to points in other parts of the country because tariffs have not been established. The present (1941) rate for wood pulp, wet or dry, from Spokane to Appleton, Wisconsin, is 57 cents per hundred pounds based on a 70,000-pound minimum load. This rate is the same as from the Pacific Coast to Appleton.

Whether wood pulp can enter Lake States markets if the rate from the Pacific Coast is identical is certainly questionable. The answer is probably "No." Obtaining a fair and equitable freight rate will mean a great deal to a new pulp mill. The subject of Lake States' markets has already been discussed and nothing more need be said along that line.

Labor Supply

Wage rates in the region tend to be higher than in the Lake States but lower than in the Pacific States. There is an adequate supply of labor in the region which would fit admirably into the woods operation of a pulp company. For the semiskilled and skilled jobs in a pulp mill, however, it would be necessary to seek elsewhere until local men were trained.

Possibilities of Shipping Pulp Logs to Lake States

In 1939 and again in 1940 shipments of Engelmann spruce logs were made to the Nekoosa-Edwards Paper Company, a Wisconsin firm, by E. C. Snook and Sons of St. Maries, Idaho. In 1939 several carloads were shipped as a trial and in 1940 it is reported that 3 million feet were shipped; some reports say 5 million.

The logs were cut into 22-foot lengths, peeled, and loaded two lengths to a gondola. The freight rate is $7 per cord, which is roughly equal to $14 per thousand feet log scale. If 22 cords (11 M feet) are loaded in a car, the revenue to the railroad company comes to about $154. If a carload of wood pulp of the same weight as the logs is shipped from Spokane to the same point it yields a revenue of about $400, which shows that from the standpoint of the railroad company the hauling of rough pulpwood probably is not lucrative.

It is reported that the price paid in 1939 for logs delivered in Wisconsin was $26 per M feet, and with freight deducted ($14 per M) the amount available for putting the logs on the car came to $12 per M feet. Of this amount $2.75 is paid for peeling the logs, a cost item which is not encountered in normal logging operations. It is reported that in 1940 a higher price was paid for the logs delivered in Wisconsin; how much higher is not known.

Possibilities of Shipping Pulp Chips to Lake States

The writer made a cursory investigation of the possibilities of shipping pulp chips, but the proposal seems to have little merit for the reason that loose chips occupy more space than the wood from which they are made, and the load in a boxcar would be considerably less than the weight capacity of the car. Shipping baled chips has a trifle more merit but it, too, has poor possibilities.

A boxcar 40 feet long by 8-1/2 feet by 8-2/3 feet has a volume of 2,890 cubic feet. Such a car will hold a maximum of 22 cords or 1,980 cubic feet of solid wood. One cubic foot of solid wood will make 2.5 cubic feet of loose, green, gravity-settled pulp chips; and if the car is loaded up to the roof with loose, green pulp chips the volume of solid wood will amount to only 1,150 cubic feet, or 60 percent as much. Although the chips contain no defects of the log, such as knots, splinters, shives, rot, etc., the lower volume of wood per car is a militating factor.

If the chips were baled in a hydraulic press it is quite possible that they would be about equal in volume, in terms of solid wood, to the volume of cordwood which could be loaded in the same car. Shipping baled chips might be worthy of further study if there were large volumes of waste material available which could not be shipped economically in their original form.

Summary of Report

The possibilities of establishing more pulp and paper mills in the Northern Rocky Mountain Region seem to center around the production of bleached sulfite pulp made chiefly from Engelmann spruce. Such pulp could probably find a market in the Lake States.

From the standpoint of Lake States investors who would be interested in producing bleached sulfite for shipment to their paper mills in the Lake States, the following statements appear to be true:

Advantages

1. The cost of wood will be much lower than in the Lake States.
2. A large volume of wood will be available for conversion.
3. Supplies of pulp for paper mills in the Lake States will be available when they are badly needed, as is the case today (1941).

Disadvantages

1. The assured markets can be reached only by a long haul.
2. A proposal to dump mill effluents into streams will cause an uproar especially in Montana where it is prohibited by statute. In Idaho and Washington the problem is less serious as these States are becoming accustomed to stream pollution.
3. The cost of labor, most chemicals, and mill supplies will be higher than in the Lake States.
4. If the period from 1934 to the forepart of 1940 is any criterion, profits, if any, will be small. (Note: The price of pulp has advanced greatly since the forepart of 1940 and present-day profits would be large.)

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The economic disposal of waste sulphite liquor. By G. H. Tomlinson and L. S. Wilcoxson. Proceedings of the annual meeting of the Technical Association of the Pulp and Paper Industry, 1940.

Characteristics of sulphite and kraft pulps from blue stained southern pine. By G. H. Chidester, M. W. Bray, C. E. Curran. Paper Trade Journal, April 7, 1938.

Report to the United States Senate on wood pulp and pulpwood. Report no. 126, second series. By U. S. Tariff Commission, 1938.

The suitability of American woods for paper pulp. By Sidney D. Wells and John D. Rue. U. S. Dept. Agric. bull. no. 1485, May 1927.

Advantages of liquid sulphur dioxide in sulphite pulp manufacture. By Vance P. Edwardes, Forest Products Laboratory. March 24, 1920.

Suggestions for a national forest policy. By committee on forest conservation of the American Pulp and Paper Association. November 14, 1919.

New pulpwood species. By C. E. Curran, Forest Products Laboratory. Date unknown.